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Spitzer Space Telescope Observations of Circumbinary Dust Disks around Polars

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Abstract. We present Spitzer Space Telescope IRAC photometry of the magnetic cataclysmic variables EF Eri, MR Ser, VV Pup, V834 Cen, GG Leo and V347 Pav. When we combine our results with the 2MASS data, we find that at least five of the polars have flux densities in the mid-IR in excess of the emission expected from the stellar components alone. We are unable to model this mid-IR excess with cyclotron emission, but we can recreate the observed spectral energy distributions with the inclusion of a simple circumbinary dust disk model. Importantly, we find that the masses of our modelled disks are approximately 12 orders of magnitude lower than required to significantly affect CV evolution. The accretion disk-less polars are ideal places to search for these disks, since the luminous accretion disk in most CVs would drown out the faint IR signature of the cooler, dimmer circumbinary disks.

1. Introduction

Polars are mass-transferring binary systems with a white dwarf magnetic field strong enough to disrupt the accretion stream from the secondary star and prevent the formation of an accretion disk around the primary star. This makes them ideal systems for the study of the cool system components such as low-mass secondary stars and dust in the outer regions of the system, as the infrared spectral energy distributions are not contaminated by flux from the cooler outer edge of an extremely bright accretion disk. The original aim of this study was to isolate the flux contribution from the low-mass secondary stars in six short-period polars, but we found that this was impossible due to a strong infrared excess from a much cooler, previously unobserved component in the systems.

2. Observations

All six polars were observed with the Spitzer Infrared Array Camera (IRAC) and the flux densities were combined with those from 2MASS to assemble the infrared spectral energy distribution (SED) from 1.2 to 8.0 μm. The measured SEDs are shown in Figure 1. In the cases of EF Eri and V347 Pav, the Spitzer and 2MASS observations were taken at different phases in the systems' photometrically-variable orbital cycles, so the IRAC flux densities were corrected to compensate. We suspect that MR Ser, GG Leo and V834 Cen were in high accretion states during the 2MASS observations as the J, H and K-band flux densities seem to show the falling Rayleigh–Jeans tail of accretion flux.

3. Model Parameters

We compared the SEDs of our polars to a model initially comprising just the white dwarf (WD) and secondary star components, using the best-measured values for the system parameters gathered from the literature. The measured and model flux densities were all scaled to a distance of 10 pc for comparison. In all cases (with the possible exception of VV Pup), we found that a model based on just the stellar components underestimated the measured flux densities in the IRAC portion of the SED. We attempted to model this excess using a cyclotron emission component, but again, this failed to match the observed IRAC flux densities, generally leading to a massive over-estimation of the $3.6 - 5.8$ μm flux densities. We find that the SEDs are best matched with the inclusion of a simple, geometrically thin, optically thick, dusty circumbinary disk, modelled as described in Dubus et al. (2004). An example of the model compared to the SED of V347 Pav can be seen in Figure 2. While the existence of circumbinary disks in CVs has been postulated before, and has even been suggested as an extra source of angular momentum loss in the systems (e.g. Taam, Sanquist, & Dubus 2003), we find that the estimated mass for our modelled disks is approximately 12 orders of magnitude too low to affect the evolution of the binary systems.

4. Conclusions

The SEDs of our polars show emission above that expected from the stellar components alone. We have tried and failed to fit the IRAC SEDs with models of the white dwarf + secondary star + cyclotron emission, and conclude that the only way to consistently fit the measured flux densities is by the inclusion of a cool, geometrically thin circumbinary dust disk. We stress that the average mass of these modelled disks is about 12 orders of magnitude too low to affect CV evolution, as calculated by Taam et al. (2003). The small number of data points and the large number of model parameters make it impossible to derive specific system parameters with any degree of certainty, so our results should only be viewed as a general overview of the properties of the class of polars

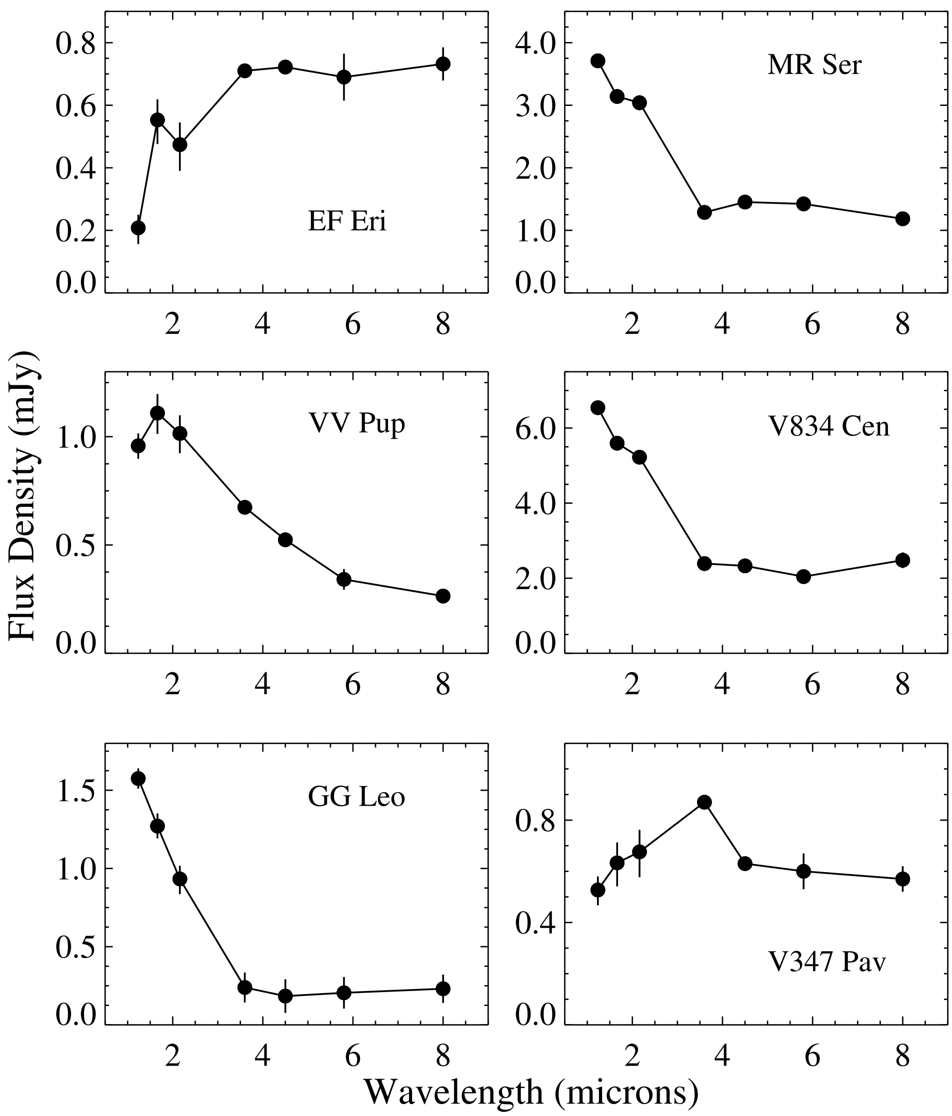

Figure 1. Measured SEDs of all six polars from 1.2 to 8.0 μm

as a whole. It is possible that these dusty disks exist in all CVs, but are only visible in those systems with low-luminosity secondary stars and no accretion disk – i.e. short-period polars. A full discussion of our results will be published in Brinkworth et al. (2006).

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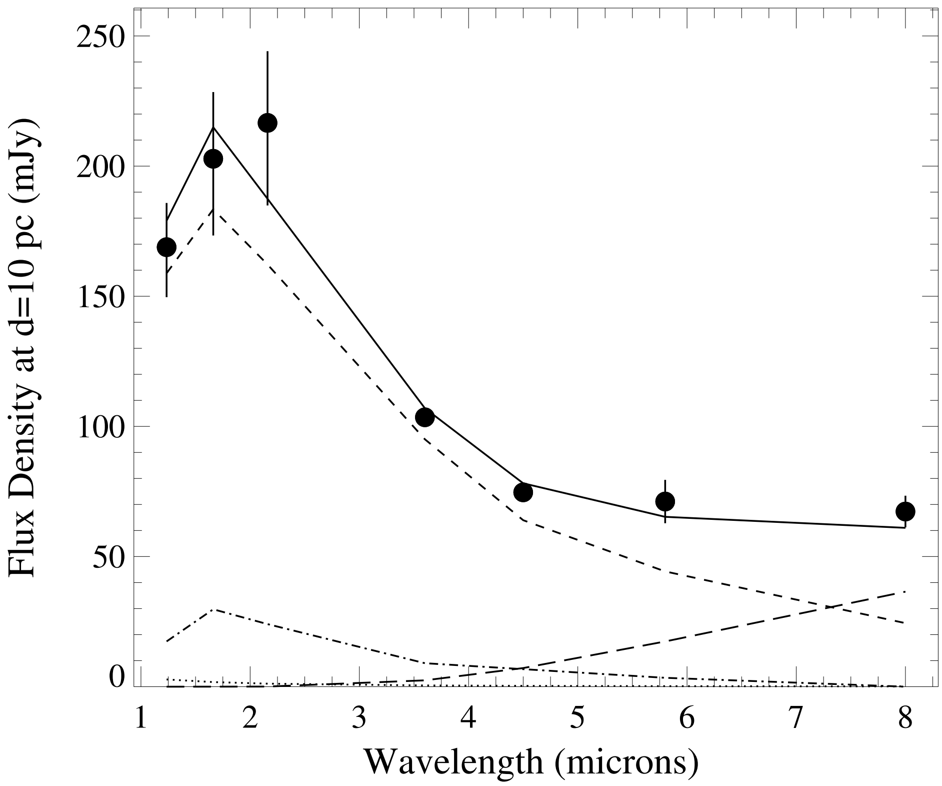

Figure 2. Example of the model fit to the SEDs (in this case for V347 Pav). Components are the white dwarf (dotted line), M7 V secondary star (short-dashed), cyclotron emission (dot-dash) and cool, geometrically thin, circumbinary dust disk (long dashed).

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References

Dubus, G., Campbell, R., Kern, B., Taam, R. E., & Spruit, H. C. 2004, MNRAS, 349, 869

Taam, R. E., Sandquist, E. L., & Dubus, G. 2003, ApJ, 592, 1124

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